UNITED STATES PATENT APPLICATION

TITLE: TENSION LEG PLATFORM HAVING A LATERAL MOORING SYSTEM AND METHODS FOR USING AND INSTALLING SAME

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BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to offshore platforms anchored to a seafloor with tendons and having a lateral mooring system (LMS) for use the oil and gas industry, where the LMS affords improved horizontal stability, improved platform positioning, improved platform installation, and improved platform operations and to methods for installing and using same.

[0002] More particularly, the present invention relates to TLPs or other similar offshore plaftorms having a lateral mooring system (LMS) for use in the oil and gas industry and in particular, to TLPs and extend-base tension leg platforms (ETLPs), where the LMS is adapted to reduce installation and/or operation costs and to provide multiple installation and/or operation performance benefits such as improved horizontal stability, improved platform installation, improved platform operations and to methods for platform positioning, installation, and operation using the LMS.

2. Description of the Related Art

[0003] Many offshore platform and platform substructures have been described in the prior art. Many of these substructures are so-called large platform support structures that anchor to the seabed by means of an array of tendons. These tendons form a pattern that define the boundaries of a relatively large area of the seabed. Compact substructures are also known in the art, but they generally employ a central column with radially disposed arms. Such large and compact platforms are disclosed in the following United States Patent Nos: 3,982,492, 4,421,436, 4,793,738, 4,913,233, 4,938,632, 4,983,073, 5,147,148, 5,381,865, 5,421,676, 5,431,511, 5,433,273, 5,549,164, 5,507,598, 5,567,086, 5,669,735, and 5,775,846, incorporated herein by reference. However, these structures do not include features of the present invention. For example, these structures do not include an array of arms or wings that radiate outwardly from a multi-columned, wave transparent substructure that minimizes or at least reduces the fatigue imposed on the anchoring tendons.

[0004] More recently, tension leg platforms including lateral extension to extend the platforms base have been developed and are the subject of U.S. Pat. No. 6,447,208, incorporated herein by

reference, incorporated herein by reference.

[0005] Although TLPs, ETLPs and other offshore platforms used in the oil and gas industry are used in many offshore drilling and production applications, there is still a need in the art for improving installation and/or operation of the such platforms, especially during initial positioning, installation, and post-installation operations.

SUMMARY OF THE INVENTION

Offshore Platforms Having a Lateral Mooring System (LMS)

[0006] The present invention provides a tendon-anchored offshore platform including a lateral mooring system (LMS), where the LMS includes a plurality of catenary mooring lines anchored to a seabed and attached to the platform, where the LMS is designed to reduce installation and/or operation costs and/or to provide installation and/or operation performance benefits and where the LMS can be attached to the platform prior to, during or after tendon installation. Preferably, mooring lines are anchored to the seabed in a spaced apart configuration surrounding an installation site of the platform, that may include buoys that adjust the vertical component of the mooring line forces acting on the platform and attached to the platform in a pattern adapted to allow the LMS to impart on the platform a force in any desired direction and directed primarily parallel to a surface of the sea due to the buoys on the mooring lines. Example of mooring lines that may not require buoys are taut leg LMS mooring lines that utilize a modified sea floor anchor.

[0007] The present invention also provides a tension leg platform (TLP) including a lateral mooring system (LMS), where the LMS includes a plurality of catenary mooring lines anchored to a seabed and attached to the platform, where the LMS is designed to reduce installation and/or operation costs and/or to provide installation and/or operation performance benefits and where the LMS can be attached to the TLP prior to, during or after tendon installation. Preferably, mooring lines are anchored to the seabed in a spaced apart configuration surrounding an installation site of the TLP, include buoys that adjust the vertical component of the mooring line forces acting on the TLP and attached to the TLP in a pattern adapted to allow the LMS to impart on the TLP a force in any desired direction and directed primarily parallel to a surface of the sea due to the action of the buoy on the mooring lines.

[0008] The present invention also provides an extended-base, tension leg platform (ETLP) including a lateral mooring system (LMS), where the LMS includes a plurality of catenary mooring lines anchored to a seabed and attached to the platform, where the LMS is designed to reduce installation and/or operation costs and/or to provide installation and/or operation performance benefits and

where the LMS can be attached to the ETLP prior to, during or after tendon installation. Preferably, mooring lines are anchored to the seabed in a spaced apart configuration surrounding an installation site of the ETLP, include buoys that adjust the vertical component of the mooring line forces acting on the ETLP and attached to the ETLP in a pattern adapted to allow the LMS to impart on the ETLP a force in any desired direction and directed primarily parallel to a surface of the sea due to the action of the buoy on the mooring lines.

[009] The present invention also provides a tendon-anchored offshore platform including a substructure supporting a deck, a plurality of tendons anchoring the substructure to a seabed under tension and lateral mooring system (LMS) having a plurality of catenary mooring lines anchored to the seabed and attached to the platform, where the LMS is adapted to reduce installation and/or operation costs and/or to provide installation and/or operation performance benefits. Preferably, mooring lines are anchored to the seabed in a spaced apart configuration surrounding an installation site of the platform, include buoys that adjust the vertical component of the mooring line forces acting on the platform and attached to the platform in a pattern adapted to allow the LMS to impart on the platform a force in any desired direction and directed primarily parallel to a surface of the sea due to the buoys on the mooring lines.

[0010] The present invention also provides a tension leg platforms (TLP) including a substructure supporting a deck, a plurality of tendons anchoring the substructure to a seabed under tension, and lateral mooring system (LMS) having a plurality of catenary mooring lines anchored to a seabed and attached to the TLP, where the LMS is designed to reduce installation and/or operation costs and/or to provide installation and/or operation performance benefits and where the LMS can be attached to the TLP prior to, during or after tendon installation. Preferably, mooring lines are anchored to the seabed in a spaced apart configuration surrounding an installation site of the TLP, include buoys that adjust the vertical component of the mooring line forces acting on the TLP and attached to the TLP in a pattern adapted to allow the LMS to impart on the TLP a force in any desired direction and directed primarily parallel to a surface of the sea due to the action of the buoy on the mooring lines.

[0011] The present invention also provides an extended-base, tension leg platforms (ETLP) including a substructure supporting a deck, a plurality of tendons anchoring the substructure to a seabed under tension, and lateral mooring system (LMS) having a plurality of catenary mooring lines anchored to a seabed and attached to the ETLP, where the LMS is designed to reduce installation and/or operation costs and/or to provide installation and/or operation performance benefits and where the LMS can be attached to the ETLP prior to, during or after tendon installation.

Preferably, mooring lines are anchored to the seabed in a spaced apart configuration surrounding an installation site of the ETLP, include buoys that adjust the vertical component of the mooring line forces acting on the ETLP and attached to the ETLP in a pattern adapted to allow the LMS to impart on the ETLP a force in any desired direction and directed primarily parallel to a surface of the sea due to the action of the buoy on the mooring lines.

Methods for Installing an Offshore Platform with Pre-Installed Tendons

[0012] The present invention provides a method for installing a tension-anchored offshore platform including the steps of roughly positioning a platform at a desired off-shore site or location. Once roughly positioned, a plurality of seabed anchored lateral mooring lines are attached to the platform. After attaching the mooring lines, the lengths of the mooring lines are adjusted to position and hold the platform on the station (meaning that the platform is maintained substantially at a given position on the surface of the sea or body of water). Once the platform is on station, the platform is ballasted and pre-installed tendons are attached to tendon connectors a base of the platform. After tendon attachment, the platform is deballasted to tension the tendons. After tensioning, the mooring lines may be disconnected, but preferably, the lines are left attached to the platform and are used during post-installation operations to reduce horizontal displacement of the platform due to wind and/or sea currents by adjusting the lengths of the mooring lines to impose a force substantially equal and opposite to the environmental forces acting on the platform. Preferred platforms includes spar platforms, tension leg platforms and extended-base tension leg platforms.

[0013] The present invention also provides a method for installing an tendon-anchored offshore platform including the steps of attaching a plurality of temporary stabilization modules to platform and transporting the platform near a desired off-shore site or location. Once the platform is positioned near the desired site, a lateral mooring system including a plurality of seabed anchored lateral mooring lines are attached to the platform. After line attachment, the lengths of the mooring lines are adjusted to position and hold the platform on station. Once the platform is on station, the platform is ballasted and pre-installed tendons are attached to tendon connectors on a base of the platform. After tendon attachment, the platform is deballasted to tension the tendons and the stabilization modules are detached and removed. After tensioning, the mooring lines maybe disconnected, but preferably, the lines are left attached to the platform and are used during post-installation operations to reduce horizontal displacement due to wind and/or sea currents by adjusting the lengths of the mooring lines to impose a force substantially equal and opposite to the environmental forces acting on the platform. Preferred platforms includes spar platforms, tension

leg platforms and extended-base tension leg platforms.

Installation of Tension Leg Platforms and Tendons

[0014] The present invention provides a method for installing a tendon-anchored offshore platform including the steps of transporting the platform near an installation site. Once positioned near the installation site, a lateral mooring system (LMS) including a plurality of seabed anchored mooring lines are attached to the platform. After LMS attachment, lengths of the lines are adjusted to position the platform over a pre-installed seabed tendon anchor. A tendon is then attached to a working part of a drilling rig associated with a deck of the platform. The tendon is then lowered until a distal end of the tendon having an anchor connector is positioned directly above a tendon connector associated with the tendon anchor. The anchor connector associated with the distal end of the tendon is then stabbed into the anchor with sufficient force so that the anchor connector and the tendon connector lockingly engage to form an installed tendon. Once installed, the lengths of the mooring lines of the LMS are adjusted to position the platform above another pre-installed seabed tendon anchor and the tendon installing process is continued until all tendons have been installed. After tendon installation, the platform can be attached to the tendons as described above for installation of a platform at a site having pre-installed tendons.

Using a Tension Leg Platform Having an LMS for Drilling a Wells at a Site

[0015] The present invention provides a method for drilling wells at a desired site using a tendon-anchored offshore platform including the steps of transporting the platform near a drilling, production and installation site. Once positioned near the installation site, a lateral mooring system (LMS) including a plurality of seabed anchored mooring lines are attached to the platform. Once the platform is positioned near the desired site, a lateral mooring system including a plurality of seabed anchored lateral mooring lines are attached to the platform. After line attachment, the lengths of the mooring lines are adjusted to position and hold the platform on station above one of the wells to be drilled. Once the platform is on station, the platform is ballasted and pre-installed tendons associated with the well to be drilled are attached to tendon connectors on a base of the platform. After tendon attachment, the platform is deballasted to tension the tendons and drilling can begin. Once the well is drilled and capped, the platform can be repositioned over a new well via the LMS and the steps are repeated until all the wells associated with the site have been drilled. After well drilling, the platform can be installed in a producing site or repositioned over each well for riser installation and then installed at a producing site, where the riser can be attached for site production. Preferred platforms includes spar platforms, tension leg platforms and extended-base

tension leg platforms.

[0016] The above apparatuses and methods can also include the use of temporary stabilization modules such as those described in U.S. Pat. No. 6503023 and co-pending U.S. Pat. Appln. No. 10/284495, filed 30 October 2002, incorporated herein by reference.

DESCRIPTION OF THE DRAWINGS

[0017] The invention can be better understood with reference to the following detailed description together with the appended illustrative drawings in which like elements are numbered the same:

[0018] Figure 1A depicts a side view of a preferred embodiment of a tension leg platform including tendons and lateral mooring lines;

[0019] Figure 1B depicts a top view looking down at a wing of the extended-base tension leg platform of Figure 1A evidencing the distribution of tendons and lateral mooring lines associated with each wing and corner of the platform;

[0020] Figure 2A depicts a side view of a preferred embodiment of an extended-base tension leg platform including tendons and lateral mooring lines;

[0021] Figure 2B depicts a top view looking down at a wing of the extended-base tension leg platform of Figure 2A evidencing the distribution of tendons and lateral mooring lines associated with each wing and corner of the platform;

[0022] Figure 3A depicts a top view of another preferred embodiment of an extended-base tension leg platform including tendons and lateral mooring lines;

[0023] Figure 3B depicts a top view of a preferred embodiment of a circular tension leg platform including tendons and lateral mooring lines;

[0024] Figure 4A-D depicts a preferred method for installing a tension leg platform (TLP) having a lateral mooring system (LMS) for a site having pre-installed tendons;

[0025] Figure 5A-D depicts a preferred method for installing a tension leg platform (TLP) having a lateral mooring system (LMS) including installing of tendons using the TLP and associated LMS for a site having pre-installed tendon anchors; and

[0026] Figure 6A-C depicts a preferred method for drilling fields using a tension leg platform (TLP) having a lateral mooring system (LMS) including installing of tendons using the TLP and associated LMS for a site having pre-installed tendon at each drilling site.

DETAILED DESCRIPTION OF THE INVENTION

[0027] The inventors have found that a new mooring system specifically tailored to the unique features of offshore platforms especially tension leg platforms (TLPs) and extended-base tension

leg platforms (ETLPs) can be constructed, where the system reduces costs associated with installation and/or operation of the platforms and provides multiple installation and/or operation performance benefits. The new mooring systems of this invention include both a tension leg mooring system and a lateral mooring system (LMS) and are well-suited for mild metocean conditions, such as those offshore W Africa and Brazil, but may also find application in oceanic regions having more severe conditions.

[0028] A substantial portion of the costs of using an TLP or ETLP for offshore operations is related to their installation. Costs associated with heavy lift crane vessels represent a major share of the installation costs. Using the LMS systems of this invention can reduce or even eliminate the need for the heavy lift crane vessels during installation, thus, making TLPs and ETLPs a more attractive commercial offering for offshore installations subject to mild metocean conditions or even more severe oceanic conditions.

[0029] The LMS of this invention can be adjustable at need or can be made dynamic, *i.e.*, the system would continually adjust lengths of the mooring lines to maintain the platform in a substantially zero net force condition. To make the LMS dynamic, each mooring line attachment system at the platform (the winches, winch motors and the winch controllers) are equipped with force sensors such as strain gauges or the like as are the tendons. The output of these force sensors are input to an analog processing unit (APU) and/or digital processing unit (DPU) via a hard wired or wireless communication system. The APU and/or DPU receives force information from each force sensor continuously or periodically and adjusts the lengths of the mooring lines to maintain a desired platform configuration or to maintain the platform in a substantially zero-net-force condition on a periodic or continuous basis. Thus, the LMS can be used as a dynamic force compensation system during standard operation or during adverse weather and sea conditions and/or events.

[0030] Suitable APU include, without limitation, any analog circuitry capable of receiving and processing input signals and capable of producing and sending output signals, where the input signals represent force measurements and the output signals represent control signals for the mooring lines. Suitable DPU include, without limitation, any digital circuitry capable of receiving and processing input signals and capable of producing and sending output signals, where the input signals represent force measurements and the output signals represent control signals for the mooring lines. Preferred DPU include, without limitation, computers and computer systems including a processing unit made but such manufacturers a Intel, Sun Microsystems, Motorola, IBM, Compaq, HP, or other manufacturers. The APUs and/or DPUs can be a single unit or a collections

of units linked together via a communication system using standard hardware and software. The APUs and/ DPUs can also include st andard and yet to be invented peripherals including user interfaces, displays devices, storage devices, memory, buses between processing unit or any other type of peripheral.

[0031] Suitable force sensor include, without limitation, strain gauges, pneumatic gauges, hydraulic gauges, load cells or any other sensor capable of measuring for force, magnitude alone or magnitude and direction.

Offshore Platforms with a Lateral Mooring System

[0032] The present invention broadly relates to an offshore platforms including a tension mooring system and a lateral mooring system (LMS). The tension mooring system includes a plurality of tendons anchored to a seabed and attached to the platform designed to hold the platform on station at a given oceanic site in a tensioned configuration. The LMS includes a plurality of lateral catenary mooring lines anchored to a seabed and attached to the platform designed to reduce installation and/or operation costs and to provide installation and/or operation performance benefits. Preferably, the platform is a tension leg platform or a extended-base tension leg platform, but cylindrical spar or other tensioned platforms can be used as well.

[0033] Preferably, the seabed ends of the mooring lines are anchored to the seabed at anchor points distributed in a space apart configuration about a center point of the site, where the configuration is designed to allow the position of the platform to be changed during installation and/or operations about a region surrounding the installation site. For platforms that can be inscribed by a circle centered at the center point of the site, the spaced apart configuration comprises anchor points preferably distributed in a spaced apart configuration about a circle concentric with the inscribing circle, *i.e.*, having the center point as its center, and extending out a sufficient distance to achieve a desired range of platform motion about the center point of the site and/or to achieve a desired line orientation for platform installation and/or operations.

[0034] For r ectangular o r o val-shaped p latforms, t he a nchor p oints o f t he l ines a re p referably distributed about either an ellipse centered at the center point of the site, a circle centered at the center point of the site or two circles centered at a middle point of the two short sides of the platform as if the platform were properly tensioned at on station over the center point of the site. In all these distributions of the anchor points are distributed about the ellipse or circle or circles in a spaced apart configuration, and extending out a sufficient distance to achieve a desired range of platform motion about the center point of the site and/or to achieve a desired line orientation for platform

installation and/or operations.

[0035] Preferably, the platform ends of the mooring lines attach to the platform in a configuration sufficient to permit the platform to be moved in any direction quickly and efficiently simply by changing the lengths of some or all of the mooring lines simultaneously. For example, if the platform includes three columns arranged in a triangular arrangement, then mooring lines are preferably attached to the platform by passing the lines through guides associated with each column and connected to line control units on the deck of the platform or associated with a portion of the platform substructure above the water line. For four column platform in a quadrilateral configuration (square, rectangular or general quadrilateral), the mooring lines are again preferably attached to the platform by passing the lines through guides associated with each column and connecting to line control units either on the deck of the platform or associated with the portion of the platform substructure above the water line. For platforms with more the four columns, the mooring lines attach to the platform at the columns in a manner similar to the manner set forth above. Preferably, two mooring lines are associated with each column in a V-shaped configuration. For cylindrical platforms, the mooring lines are attached at equally spaced points about the cylindrical exterior of the platform. Preferably, pair of lines emanate from each point in a V-shaped configuration.

[0036] Although it is preferred to have the mooring lines attached to the platform at the columns because the guides can be secured to an above water line portion of each column, the mooring lines can also be attached to the platform at other locations such as in a middle portion of the sides of the platform at any other part of the platform not associated with the columns which are generally located at vertices of the platform shape. In both the vertex moored configuration or column moored configuration and the side moored configuration (lines anchored at any site other than the columns), there should be sufficient mooring lines so that platform positioning during installation can be achieve quickly and easily either during installation or to achieve force compensation during operation to maintain the platform in a substantially force free state.

[0037] The mooring lines generally include a buoy which allows the mooring lines to impart a greater horizontal force to the platform than would be the case if the lines did not have a buoy associated therewith. The lines used in this invention can be metal, composite or polymeric or combinations thereof depending on the application, cost and other factors. Preferred metals include, without limitation, steels or other iron alloys or combinations thereof. Preferred composites include, without limitation, carbon fiber or aramide composites or combinations thereof. Preferred

polymeric lines include, without limitation, multi-stranded polyester, polyamide, or the like or combinations thereof. Preferably, the lines are sea water resistant, steel cables or polyester or polyamide cables or combinations thereof.

[0038] The mooring lines are controlled at their platform ends by line take-up and let-out systems installed either on the deck of the platform or in or on a portion of the substructure above the water line. The control systems can be manually controlled or computer controlled and either control format can include remote control depending on the installation requirements. Generally, the line control systems are winches with motors to control take-up and let-out. These winches can controlled by a digital and/or analog processing unit so that all the winches can be adjusted simultaneously and/or dynamically.

[0039] For dynamic control, the computer (DPUs and/or APUs and/or system of APUs and/or DPUs) would need data concerning the length of each line, forces acting on each line, and horizontal forces acting on the platform. The forces acting on the lines can be determined either directly from the winch or via force measuring devices or sensors attached to the winch and/or to the lines. The forces acting on the platform can be determined by force sensing devices or sensors attached to or associated with the tendons, with the tendon porches where the tendons attach to the platform or with the feet of the tendons where the tendons anchor to the seabed or any combination thereof. By determining the forces acting on the tendons, the computer determines a direction and magnitude of a composite force acting on the entire platform.

[0040] After determining the direction and magnitude of the composite force, the computer determines adjustments to the length of the mooring lines to produce a force of substantially equal magnitude to the composite force, but in a direction substantially opposite the direction of the composite force. Adjustment continues until the platform is in a substantially zero-force state. Of course, the computer can either continuously or periodically monitor the force sensors and adjust the lines accordingly. Such dynamic control would require variable speed winch motors and a robust communication system between the computer, the force sensor and the line controllers.

Platform Installation Using an LMS

[0041] The present invention also broadly relates to methods for installing tendon anchored, offshore platforms. One preferred method for platform installation at a site having a pre-installed tensioning system including a plurality of pre-installed, seabed anchored tendons and a pre-installed lateral mooring system (LMS) including a plurality of seabed anchored mooring lines, involves transporting the platform at a desired offshore site or location via ship or tugs or the like. After

transportation, the LMS is attached to the platform and the lengths of the mooring lines are adjusted to place and hold the platform on station over the site for tendon connection. The platform is then ballasted and the tendons attached to tendon connectors associated with a bottom portion of the platform substructure such as a tendon porch. After tendon connection, the platform is deballasted until a desired tendons tension is achieved completing platform installation. After installation, the LMS can be removed, but preferably the LMS is not removed and is used to maintain the platform in a substantially zero-force condition.

[0042] Another preferred method, designed for platform installation at a site having a plurality of pre-installed tendon anchors and a pre-installed lateral mooring system (LMS) including a plurality of mooring lines, involves transporting the platform to a desired offshore site or location via ship or tugs or the like. After transportation, the LMS is attached to the platform and the lengths of the mooring lines are adjusted to place and hold the platform on station over one of the pre-installed tendon anchors. A tendon is then attached to the working end of a drilling rig associated with a deck of the platform. The attached tendon includes a tendon anchor connector at is distal end and a tendon buoyancy module connect at or near its proximal end and the tendon anchor includes a tendon connector, where the two connectors are designed to lockingly engage each other anchoring the tendon to the tendon anchor. The distal end of the tendon is then lowered or directed to tendon anchor and stabbed into the tendon anchor with sufficient force to permit the two connectors to lockingly engage anchoring the tendon. The platform is then positioned and held on station over the next tendon anchor and another tendon is stabbed into place. After all of the tendons have been installed, the site now is equivalent to a site having a pre-installed tendons. As stated above, the platform is then positioned on station over the installation site and ballasted so that the tendons can be attached to tendon connectors associated with a bottom portion of the platform such as a tendon porch and deballasted until a desired tendon tension is achieved completing platform installation.

[0043] The present above method can also include the steps of attaching a plurality of temporary stabilization modules to the platform in a module spaced apart configuration either before or after transportation, but before platform and/or combined tendon/platform installation. The temporary stabilization modules are then be removed after tendon tensioning.

Site Drilling Using a Moveable Tendon-Based Platform Having an LMS

[0044] Another preferred method using an LMS attached to a tendon-based offshore platform is designed to allow the tendon-based offshore platform to be used as a repositionable drilling platform for an oceanic site, which is intended to have a plurality of producing wells. The method involves

transporting the platform to a desired offshore site or location via ship or tugs or the like. After transportation, the LMS is attached to the platform and the lengths of the mooring lines are adjusted to place and hold the platform on station over one of the well sites to be drilled. Each well site can either include pre-installed tendons for direct platform attachment or pre-installed tendon anchors which can be used to install tendons at the site. In either case, after tendon attachment and platform tensioning, a well is drilled at the site. After the well is drilled and capped, with or without riser attachment, the platform is deinstalled by ballasting the platform, disconnected from the tendons, which can be recovered if the tendons are releasably connected to the tendon anchors, and using the LMS to reposition the platform over the next well site. This process is continued until all of the well are drilled. After all well are drilled, the platform can be repositioned above each site for riser installation. Finally, the platform can be repositioned to its permanent production site and installed. After permanent installation, the risers can be attached to the platform converting the platform into a production platform.

ILLUSTRATIVE PREFERRED EMBODIMENTS

The following detailed description of the drawings associated with this invention are included to illustrate preferred embodiments of this invention, but are not intended to limit the scope of this invention.

Tendon-Based Offshore Platforms Having an LMS

[0045] Referring now to Figures 1A&B, a preferred tension leg, laterally moored, platform (LMS-TLP), generally **100**, of this invention is shown to include a tension leg platform **102** having a deck **104** columns **106**, pontoons **108**, where the deck **104** is located above a water line **110**. Tendons **112** are attached at their platform ends **114** to tendon porches **116** associated with a distal end **118** of each column **106** and anchored to a seabed **120** at their seabed ends **122**. Two lateral mooring lines **124** are attached to each column **106** at their platform ends **126** to guides **128** and to the seabed **120** at their seabed ends **130** having a catenary buoy **132** interposed therebetween.

[0046] On board winches (not shown) control the mean static position, or offset, of the TLP **100**. The off-board components (*e.g.*, lines, piles and buoys) of the mooring lines can be installed prior to arrival of the TLP **100**. Mooring line piles can be installed at the same time as the tendon piles and FPSO piles, making installation a single operation. Although the TLP **100** is anchored to the seabed in the traditional way using seabed anchored tendons to tension the platform, the lateral mooring lines are useful for installing the TLP **100** by holding the TLP **100** stationary during tendon installation, during well drilling, during riser installation, during production off-loading and during

any other operation that requires some amount of TLP repositioning or force compensation to maintain the TLP in a substantially vertical orientation and/or substantially zero-force condition. The term substantially vertical means that the TLP is oriented in a manner that a horizontal off-set is less than the maximum amount of horizontal off-set the TLP is designed to withstand.

[0047] Referring now to Figures 2A&B, a preferred extended-base tension leg, laterally moored, platform (LMS-ETLP), generally **200**, of this invention is shown to include a tension leg platform **202** having a deck **204**, columns **206**, pontoons **208**, and base extensions or wings **210**, where the deck **204** is located above a water line **212**. Tendons **214** are attached at their platform ends **216** to a tendon porch **218** associated with a distal end **220** of each column **206** and are anchored to a seabed **222** on their seabed ends **224**. Two lateral mooring lines **226** are attached, at their platform ends **228**, to guides **230** associated with each column **206** and to the seabed at their seabed ends **232** with a catenary buoy **234** interposed therebetween. On board winches (not shown) control the mean static position, or offset, of the ETLP. The off-board components (*e.g.*, pile and buoy) of the LMS can be installed prior to arrival of the ETLP. LMS piles can be installed with the FPSO piles.

[0048] On board winches (not shown) control the mean static position, or offset, of the ETLP **200**. The off-board components (*e.g.*, lines, piles and buoys) of the mooring lines can be installed prior to arrival of the ETLP **200**. Mooring line piles can be installed at the same time as the tendon piles and FPSO piles, making installation a single operation. Although the ETLP **200** is anchored to the seabed in the traditional way using seabed anchored tendons to tension the platform, the lateral mooring lines a useful for installing the ETLP **200** by holding the ETLP **200** stationary during tendon installation, during well drilling, during riser installation, during production off-loading and during any other operation that requires some amount of ETLP repositioning or force compensation to maintain the ETLP in a substantially vertical orientation. The term substantially vertical means that the ETLP is oriented in a manner that a horizontal off-set is less than the maximum amount of horizontal off-set the ETLP is designed to withstand. Tension control of the LMS lines assists the ETLP tendons maintain an acceptable horizontal offset, which for some ETLPs is about 4%, allowing 100% operability during the ETLPs lifetime. As a result, tendon pretension can be reduced. A favorable consequence of pretension reduction is less hull steel and tendon downsizing.

[0049] Referring now to Figure 3A, another preferred LMS-ETLP, generally **300**, of this invention is shown to include a tension leg platform substructure **302** having columns **304**, pontoons **306**, and base extensions or wings **308**. Four lateral mooring lines **310** with associated buoys **312** are attached to guides **314** associated with each column **304** at their platform ends **316**. Two of the lines

310 are attached to guides **314** on an outer face **318** of each column **304** above the wings **308**.

[0050] Referring now to Figure 3B, another preferred LMS-TLP, generally **350**, of this invention is shown to include a circular tension leg platform substructure **352** having two lateral mooring lines **354** with associated buoys **356** attached at four locations **358** of the substructure **352**.

[0051] Again, on board winches (not shown) control the mean static position, or offset, of the substructures **300** and **350**, and the off-board components (*e.g.*, lines, piles and buoys) of the mooring lines can be installed prior to arrival of the substructures.

Installation of Tension Leg Platforms Having Pre-Installed Tendons

[0052] Referring now to Figures 4A-D, the LMS of this invention can be used to assist in TLP or ETLP installation allowing the TLP or ETLP to be quickly and effectively positioned and repositioned for tendon attachment and tensioning. Looking at Figure 4A, an ETLP, generally **400**, is shown to floating in a body of water **402** having a surface **404** and a bed **406** and a first position **408**. The ETLP **400** includes a deck **410** having a drilling rig **412** and a substructure **414** having columns **416**, pontoons **418**, wings **420**, tendon connectors **422** and a mooring lines **424**, only two of which are shown. The mooring lines **424** include a buoy **426**, are attached to the ETLP **400** via guides **428** terminating in winches (not shown) located in the deck section **410** of the ETLP **400** and are anchored to the seabed **406** at an anchors **430**.

[0053] Looking at Figure 4B, by changing the lengths of the mooring lines **424**, the ETLP **400** can be repositioned to a second position **432** where at least one tendon connector **422** lines up with a top connector **434** of at least on pre-installed tendon **436**. Looking a Figure 4C, the ETLP **400** is kept at the position **432** by the mooring lines **424**, while the ETLP **400** is being connected to the tendons **436** via the top connectors **434** and the tendon connectors **422**, ballasted and deballasted to tension the tendons **436**. Of course, the lengths of the mooring lines **424** may need to be adjusted during this operation to change or adjust the position of the ETLP **400** so that each tendon connector **422** can be connected to its corresponding top connector **434** on its associated tendon **436**. Looking at Figure 4D, the ETLP **400** is shown fully installed and tensioned.

Installation of Tension Leg Platforms and Tendons

[0054] Referring now to Figures 5A-D, the LMS of this invention can be used to assist in TLP or ETLP installation allowing the TLP or ETLP to be quickly and effectively positioned and repositioned for tendon installation, attachment and tensioning. Looking at Figure 5A, an ETLP, generally **500**, is shown floating in a body of water **502** having a surface **504** and a bed **506** at a first position **508**. The ETLP **500** includes a deck **510** having a drilling rig **512** and a substructure **514**

having columns **516**, pontoons **518**, wings **520**, tendon connectors **522** and a mooring lines **524**, only two of which are shown. The mooring lines **524** include a buoy **526**, are attached to the ETLP **500** via guides **528** terminating in winches (not shown) located in the deck section **510** of the ETLP **500** and are anchored to the seabed **506** at an anchor **530**. The first position **508** is in proximity of a plurality of tendon anchors **532** having a tendon connector **534** located on the seabed **506**.

[0055] The ETLP **500** also includes a tendon **536** having a tendon anchor connector **538** at its distal end **540** and tendon buoy module **541**. The tendon **536** is attached to a cable or wire line **542** connected to the working part (not shown) of the rig **512** so that the tendon **536** can be lowered to one of the tendon anchors **532** for tendon installation. Once lowered to a tendon anchor **532**, the tendon anchor connector **538** stabs into the tendon connector **534** associated with the anchor **532** to form an installed tendon. Of course, the stabbing force mus be sufficient enough to lock the tendon **536** in place and the connectors **534** and **538** must lock with sufficient rigidity to withstand platform tensioning and normal post installation force fluctuations. Such tendon stabbing systems are described in United States Pat. Nos.: ?, incorporated herein by reference.

[0056] Looking at Figure 5B, by changing the lengths of the mooring lines **524**, the ETLP **500** is repositioned to a second position **544** where the tendon **536** lines up with one of the tendon anchors **532**. The cable **542** connecting the tendon **536** to the working part of the rig **512** is then lowered until the tendon anchor connector **538** is stabbed into the anchor **532** with sufficient force to cause the tendon connector **534** of the anchor **532** to lockingly engage the connector **538** of the tendon **536**. Looking a Figure 5C, the tendon installation process is repeated by attaching another tendon **536** to the working part of the rig **512**, repositioning the ETLP **500** to a third position **546** by adjusting the lengths of the mooring lines **524**, and stabbing the tendon **536** into the anchor **532** with sufficient force to cause the tendon connector **534** of the anchor **532** to lockingly engage the connector **538** of the tendon **536**.

[0057] After all of the tendons **536** have been installed by the above described repositioning and stabbing process, the ETLP **500** is repositioned to an installation position **548** as shown in Figure 5D. The tendon buoy modules **541** are removed and ETLP **510** is lowered in the water and top tendon connectors **550** are connected to the platform tendon connectors **522**. The ETLP **510** is then raised to installation depth tensioning the tendons **536** completing the installation process.

[0058] Thus, the mooring lines associated with the tension leg platforms of this invention are used to winch the free floating TLP or ETLP over the first pre-installed tendon pile with associated seabed connector. The drilling rig is then be used to vertically stack the tendon sections one by one

to form a tendon having an anchor connector at its bottom. The fully assembled tendon with tendon buoyancy module fits easily through the open wellbay. When fully assembled, the tendon string is then stabbed into the connector associated with the pre-installed tendon pile or anchor and left free-standing. This procedure is repeated for the remaining seven tendons, for an eight tendon tension leg platform. This tendon installation procedure is performed without the need of a heavy lift crane vessel.

[0059] Having installed all of the tendons, the ETLP accurately positions itself with the LMS. The tendon tops are pulled aside and ballasting of the ETLP is begun. When lock-off draft is achieved, the tendons are allowed to return back to vertical and are guided into the side-entry porches. Deballasting is begun and continues until the proper tendon pretension level is reached. After final tension adjustments are made the ETLP is weathersafe. Temporary stability modules and tendon buoyancy modules are removed and the ETLP is ready for operation. Again, this ETLP self-installation procedure just described is performed without the need of a heavy lift crane vessel.

LMS Assisted TLP Site Drilling

[0060] Referring now to Figures 6A-C, an LMS of this invention is used to assist an TLP or ETLP in drilling or completing an offshore oil field having a plurality of subsea wells. Looking at Figure 6A, an ETLP, generally **600**, is shown floating in a body of water **602** having a surface **604** and a bed **606** over a drilling site **608**. The ETLP **600** includes a deck **610** having a drilling rig **612** and a substructure **614** having columns **616**, pontoons **618**, wings **620**, tendon connectors **622** and a mooring lines **624**, only two of which are shown. Each mooring line **624** extend from a seabed anchor **626** at its distal end **628** to the ETLP **600** via guides **630** to winching systems (not shown) located on the deck **610** or in the substructure **614** above the water surface **604**. Each mooring line **624** also includes a buoy **632** positioned along the line **624**.

[0061] After the ETLP **600** attachment of the mooring lines **624**, the ETLP **600** can be repositioned over a plurality of pre-installed tendons **634a-d** associated with locations **636a-d** on the seabed **606**, which can correspond to either drilling sites or pre-existing wellheads that require riser installation. The tendons 634a-d has buoyant modules **638a-d** associated therewith. The mooring lines **624** are used position the ETLP **600** over each location **636a-d** so that a well can be drilled or a riser can be installed. Looking at Figure 6B, the mooring lines **624** are used to position the ETLP **600** over the location **636a** and the ETLP **600** is then installed using the pre-installed tendons **634a** associated with the site **636a** as shown in Figure 6B. Once installed at the site **636a**, the ETLP **600** is used to drill a well as shown in the figure at the site **636a**. After drilling is completed at site the **636a**, the

ETLP **600** is deinstalled from the pre-installed tendons **634a** and positioned over the site **636b** via the mooring lines **624**. Once positioned over the site **636b**, the ETLP **600** is installed over the site **636b** using the pre-installed tendons **634b** associated therewith and a well is drilled at that site as shown in Figure 6C. This process is continued until wells are drilled at all of the sites **636a-d** using the mooring lines **624** and the pre-installed tendons **634** a-d associated with each site. Of course, for well distribution patterns of this invention, the number of wells and their layout would be consistent with a closely packed perimeter production platform which can be the ETLP itself or a secondary installation to be installed later.

[062] It should be recognized by an ordinary artisan that the above process does not need to utilize pre-installed tendons. Utilizing the process described in connection with Figure 6A-C, the ETLP or TLP can be used to installed the tendons at piles sites associated with each drilling site in the drilling pattern. If the tendons are also disconnectable, then the tendons can be installed and deinstalled and reinstallated at each new drilling site so that only one set of tendons is left after field complete and riser installation.

[063] Utilizing a LMS allows the ETLP to winch itself directly over the seafloor wellhead similar to a Spar platform. The drilling rig can be fixed in the middle of the open wellbay. Since a skidable rig is no longer necessary, a majority of trim ballast can be eliminated. A favorable consequence of trim ballast reduction is less hull steel and tendon downsizing. In addition, a substantial amount of steel can be removed from the rig's substructure. Guidelines and associated equipment can also be eliminated.

[064] All references cited herein are incorporated herein by reference. While this invention has been described fully and completely, it should be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. Although the invention has been disclosed with reference to its preferred embodiments, from reading this description those of skill in the art may appreciate changes and modification that may be made which do not depart from the scope and spirit of the invention as described above and claimed hereafter.